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EFFECTS OF ORTHOKINETIC SEGMENTS UPON MOTOR RESPONSES OF NORMAL MALE COLLEGE STUDENTS.
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THIS STUDY ASSESSES THE EFFECTS OF ORTHOKINETIC SEGMENTS UPON THE MOTOR RESPONSES OF NORMAL MALE COLLEGE STUDENTS PERFORMING THE VERTICAL JUMP AND THE STANDING BROAD JUMP. THE VARIOUS PLACINGS OF THE ELASTIC AND INELASTIC FIELDS OF THE SEGMENTS UPON THE AGONIST AND ANTAGONIST THIGH MUSCLES OF STUDENTS WERE NOTED AND COMPARED WITH PERFORMANCE SCORES TO DETERMINE IF THE SEGMENTS FACILITATED, INHIBITED, OR FAILED TO SIGNIFICANTLY AFFECT PERFORMANCE. ORTHOKINETICS MAY ASSIST IN THE DEVELOPMENT OF COORDINATION AND MOTOR SKILLS BY EXTERNAL MEANS, AND IS A METHOD OF STUDYING THE NERVOUS SYSTEM OF THE LIVE ORGANISM. CONCEPTS OF THE NERVOUS SYSTEM, DERIVED FROM NEUROANATOMISTS AND NEUROPHYSIOLOGISTS, ARE RELATED TO ORTHOKINETICS. THE SAMPLE WAS DIVIDED INTO A CONTROL AND THREE TREATMENT GROUPS. MEASUREMENT TECHNIQUES AND STATISTICAL PROCEDURES ARE OUTLINED. NO IMMEDIATE DECISIVE EFFECTS OF THE SEGMENTS ON A NORMAL SUBJECT'S ABILITY IN EITHER THE VERTICAL JUMP OR STANDING BROAD JUMP WERE NOTED. LONGER EXPOSURE TO THE SEGMENTS MAY BE NECESSARY. A DISCUSSION OF THE RESULTS, INCLUDING A CONSIDERATION OF FACTORS INFLUENCING THE RESULTS, IS PROVIDED. (PS)

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EFFECTS OF ORTHOKINETIC SEGMENTS UPON MOTOR RESPONSES OF NORMAL MALE COLLEGE STUDENTS[1]

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Orthokinetic segments are recently invented cloth and elastic devices designed to be placed on an individual to affect his motor performance. The segments appear to enhance or inhibit motor performance, especially the motor performance of the limbs, where the placing of the elastic and inelastic portions of the segments can contact the skin directly over the prime agonist and antagonist muscles. In theory, the segments achieve their effect by stimulating the skin with subsequent involvement of the voluntary nervous system at the spinal level.

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PURPOSE OF THE STUDY

This study was made to assess the effects of orthokinetic segments upon motor responses of normal male college students performing the criterion measures of the vertical jump and the standing broad jump. The placings of the elastic and inelastic fields of the segments variously upon the agonist and antagonist thigh muscles of the students were noted and compared with performance scores to determine if the segments facilitated, inhibited, or failed to affect significantly the student's jumping performance.

SIGNIFICANCE OF THE STUDY

The specific effects of treatment by orthokinetic segments are only beginning to be known. There are only five published articles in the United States, the first having appeared only five years ago (4,5,6,31 and 72). And the work which these articles reported was clinical; that is, the application of the orthokinetic segments was done on individuals, looking toward specific individual results, and no controls were established to substantiate that the source of the effect was due to the orthokinetic treatment.

If the facilitating or inhibiting effects of these segments can be demonstrated on normal subjects in a controlled research project, the technique may be studied in depth in order to provide a means by which the learning and performance of various motor activities can be improved. Any activity necessitating the acquisition of gross motor skills--skills needed, for example, in physical education, rehabilitation programs, industry, and the military--could make important use of such a technique. In essence, orthokinetics hold promise of assisting in the development of coordination and motor skill learning by external means. It suggests that spinal motor nerve cells may be recruited without cortical involvement by externally stimulating the skin covering the related muscle. Furthermore, if the technique can be demonstrated to have a general applicability, it will provide a valuable means by which to investigate the nervous structure of the live, intact organism.

BACKGROUND

Orthokinetics. The idea of using orthokinetic segments is quite modern. Apparently Dr. Julius Fuchs, an orthopedic surgeon practicing in Germany and later in the United States, was the first to develop the theory of orthokinetic treatment, making the first use of it in the period beginning with World War I and continuing until his death in 1953. Dr. M. R. M. Blashy, now chief of the Physical Medicine and Rehabilitation Service at the Veterans Hospital at Temple, Texas, and translator of Dr. Fuchs's book, has published the results of his own work with orthokinetic segments. The writings of these two men form the basic theory of orthokinetics.

In 1951 Dr. Fuchs reported on his work with orthokinetics, a term which appears to be his creation. In New York Physician and American Medicine (32) he gives the derivation of the word as follows: "The word orthokinetics is derived from two classical Greek roots, orthos, meaning correct, and kineo, meaning to move." He asserted that in diagnosing a dysfunction of any part of the body all the moving parts should be considered and that "kinetic chains," constitute a fundamental diagnostic concept. He believed that one could develop an "active" orthopedic device which would produce controlled muscle action and could, therefore, replace solid circular casts. Fuchs's clinical work gave him the idea, but his subsequent study of nerve responses and muscular coordination apparently provided him with the insight to invent the orthokinetic segment. After developing a method of treatment in 1923 Fuchs claimed to have used the segments with success in the treatment of more than 12,000 patients with neuromuscular or bone dysfunctions.

Fuchs's segments were constructed from the skins of young or unborn calves. These skins, which have elastic properties, were molded in a tubelike manner on the patient. Once the segment was placed on the patient's limb, certain parts of it were chemically treated to destroy the elasticity; thus, elastic and inelastic fields were devised which covered the surface area of the muscles in conjunction with which the orthokinetic effect was to be achieved.

It appears, then, that Fuchs initiated the idea of using elastic and inelastic segments on the human body, and offered evidence of their efficaciousness by successful therapeutic use. He began the search for an understanding of the orthokinetic relationship of body parts but did not choose to theorize in depth on the means by which his segments worked, perhaps because the state of knowledge of neuroanatomy at the time he worked and wrote offered little incentive.

Later, Dr. M. R. M. Blashy, a German-trained doctor of medicine, became interested in orthokinetics and translated Fuchs's work (31) to English for his own use in therapy. In several reports Blashy described his own orthokinetic treatment method and the results from it (4,5,6). Blashy modified Fuchs's original orthokinetic segments by constructing the segments from elastic bandage. The elastic field was made up of three or more layers of elastic bandage which stretched transversely to the length of the muscle. The inelastic field was made up of two layers of this same elastic material but with a piece of plain canvas sewn in between to make the field inelastic. Blashy strongly emphasized that while "bandaging" material was used the orthokinetic segments did not function as a bandage but, rather, constituted a unique orthopedic device.

Orthokinetic therapy was to be suited to the individual. Blashy recommended careful measurement of the traumatized muscle and the related muscles with special attention being given to the relative areas to be covered by the elastic and inelastic fields. He further suggested that for even greater therapeutic effects an individually designed rotary-type exercise should be prescribed for the patient.

Blashy (6) summarized the orthokinetic effects he observed as follows: 1) facilitation and inhibition of antagonistic muscle groups reciprocally, 2) relief of pain, 3) improvement of coordination, 4) increase of muscle power in facilitated muscles, 5) increase in range of motion, 6) automatic muscle re-education, 7) retention of newly acquired movement even after removal of segments, 8) a more effective treatment when muscle imbalance was pronounced, 9) stabilization of joints, 10) the bringing about of edema by tight application of the segments (this occurred only under the inelastic field).

Capt. Joan K. Whelan, Medical Specialist Corps, U.S. Air Force, is the only other investigator to date who has published specifically on the subject of orthokinetics. Her paper (73) reported an investigation of the effects of Blashy-type segments used upon hemiplegic patients in an effort to improve postural carriage, reaction speed, muscle strength, and range of motion. Captain Whelan recommended the use of orthokinetic segments in occupational therapy programs for adult hemiplegics.

Neuroanatomy and neurophysiology. Certain concepts of the nervous system as developed by neuroanatomists and neurophysiologists outline the basic units of the system with which a theory of orthokinetics must deal. Many excellent texts (2,16,30,36) provide this information.

In addition to the elements of the system, such as nerve cells and sense organs, and of physical characteristics, such as conduction qualities and reflex arcs, various conceptualizations about over-all behavior--such as general pathways, specific reflex behaviors, and spinal localized reactions--form a framework into which the special kinetics of orthokinetics can be placed for initial understanding and assessment. In this report only the principal parts and characteristics of the framework can be touched upon to provide sufficient guidelines for general understanding.

Sense organs--the sensory origin points, also called "fiber terminations"--are differentiated according to their location in the body into four main types: the proprioceptors of the muscles, tendons, and joints; the exteroceptors of the integument; the interoceptors of the viscera; and the teleceptors of the head. Proprioceptors and exteroceptors are the ones most pertinent to this study. Proprioceptors are more explicitly called muscle spindles and tendon end organs. In the muscle spindles the nerve fibers end by winding around the intrafusal muscle of the myotube. The tendon end organ, sometimes called the Golgi tendon organ, is also the sensory organ of the joints. Muscle spindles and Golgi tendon organs are found throughout the voluntary system but occur in greater numbers in the anti-gravity muscles. Exteroceptors are encapsulated endings and axioplasmic endings which terminate at various depths in the integument.

Orthokinetic segments, if they are in fact effective, probably operate by stimuli through the exteroceptors and, because of the anatomical differences of the latter, have a varying effect. The proprioceptors report to the central

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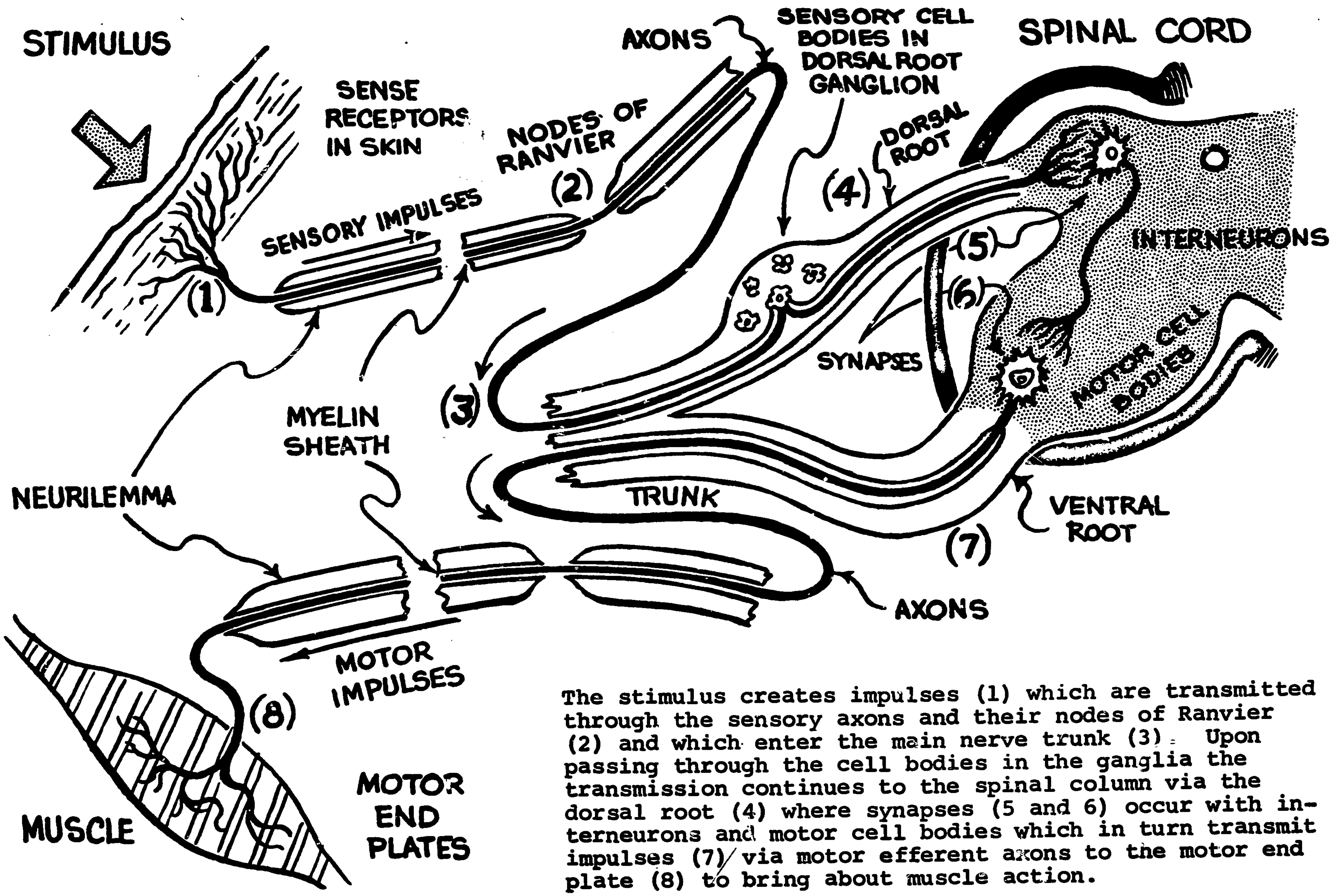
nervous system the state of contraction of the muscles and the posture of the joints, and they must be taken into account when attempts are made to explain the manner in which facilitation and inhibition occur when brought about by orthokinetic techniques.

It is important to have a "ground plan" for the entire central nervous system because orthokinetics, as Fuchs observed, inherently involves the whole organism. Figure 1 is a diagram of a reflex arc in the central nervous system--these arcs would appear to be the gross pathway of orthokinetic communication. Certain parts of the organism may be more demonstrably related to certain other parts in that there are observable physical reactions between them, but it must not be overlooked that relationships not yet discovered await the development of theory and more sensitive research devices. Sensory nerve fibers enter the spinal cord at all levels on the dorsolateral sides, while their cell bodies cluster in ganglia outside but near the cord. The fibers of the motor nerves, whose bodies are in the anterior horns of the spinal cord, exit from the cord on the ventromedial sides. Within the spinal cord there exists a system of communication between the interneurons, the motor neurons, and the fibers of the sensory nerves. Also located in the cord are the propriospinal neurons which form a system of afferent and efferent nerve fibers contained entirely within the cord and which have the apparent function of assisting in both the sensing and the motor synaptic activity (26,38). The grey and white matter of



The stimulus creates impulses (1) which are transmitted through the sensory axons and their nodes of Ranvier (2) and which enter the main nerve trunk (3). Upon passing through the cell bodies in the ganglia the transmission continues to the spinal column via the dorsal root (4) where synapses (5 and 6) occur with interneurons and motor cell bodies which in turn transmit impulses (7) via motor efferent axons to the motor end plate (8) to bring about muscle action.

Figure 1. A CENTRAL NERVOUS SYSTEM REFLEX ARC

the cord is composed, then, of nerve bodies and fibers, the synapses are the junctions of nerves, and the impulses from the various systems are able to travel both up and down and transversely. Synapses can occur fiber to fiber, fiber to several fibers, and fiber or fibers to cell body. Nerve fibers which bring information to the cord and the high centers are called afferent. Efferent fibers carry information to the effectors--the parts of the organism which produce behavior.

The sensitiveness of the entire system to activity at any part is referred to as the integrative nature of the system. Often the term integrative action is used to imply repercussions of more or less intensity throughout the system to a local stimulus (69).

Due to the extreme smallness of nerve fibers and to their great number, the actual tracing of an experimental impulse through specific routes is virtually impossible. Laboratory techniques have been developed to measure some impulses in this manner, but nerve passages for lack of more definitive route knowledge must be spoken of as "pathways." Impulses which result in observable behavior may be categorized according to the three more or less distinct pathways in which they travel (30). The protopathic pathway fibers decussate within that segment of the spinal cord where they enter and carry primitive sensations such as heat, cold, and pain from the skin, muscle strain, and sexual orgasm. Intermediate pathway fibers decussate anywhere except caudelward from the point of entry and carry sensations such as coarse touch and pressure. Fibers of the epicritic pathway decussate in the bulb only and carry sensations such as fine touch and kinesthesia. All these fibers give off collaterals which are reflex connected.

It is clear that, while the cerebrum and cerebellum form a climax to the hierarchy of muscle control centers, ample control centers exist at the spinal level to justify orthokinetic theory that facilitation and inhibition can occur at this low level and that even though the level is purely spinal, the complexity of the pathways will be great. The complexity of the voluntary nervous system at the spinal level becomes even more apparent when one considers that the commands from higher centers are literally funneled into a final common pathway made up of a very few fibers--there are only a few thousand lower motor neurons compared to hundreds of millions of efferent neurons in the higher motor centers (30). The task of directing and sorting the cortical impulses to the proper effectors in the spinal cord represents an amazingly complex system.

Looking at the system from the vantage point of muscle behavior it can be observed that in a single muscle countless grades of intensity of muscle action are possible. The term motor integrative action is applied to the co-performance of the following factors which are thought to bring about the grading of intensity: differences in nerve motor unit size, differences in the combinations of units, and differences in rates of discharge per unit (10). While these aspects of the system have no direct implication to the construction of orthokinetic theory, they are part of the framework in which reflex arcs operate--and the reflex arc concepts will no doubt be found to have vital significance to orthokinetics.

Reflex arcs are behavior forms of the nervous organization in which a response does not vary in respect to a stimulus, forms which are simple and useful to the organism and which are usually inherited. Of course, the appelation "simple" is relative; the arc is simple not as it refers to the complexity of the neuron chains involved but rather as it refers to the behavior possibilities of the organism (30).

Some of the arguments in an orthokinetic theory can be based upon generally accepted theories of reflex behavior (61). The stretch reflex, the flexor reflex, and the extensor thrust reflex are basic reflexes which show some of the possible organizations of reflexes at the spinal level and give some of the responses.

The operation of reflexes requires not only the distribution of impulses but also the regulation in some manner of intensities. The inhibition of the myotatic reflex is a concommitant regulatory reflex. It is illustrative of some of the control features believed to exist in connection with reflexes. The Renshaw cell is an interneuron which receives impulses from a collateral of the motor efferent. It apparently reacts to the quality and/or quantity of these impulses and transmits back to the motor nerve a regulatory command; *i.e.*, it prevents a directly sympathetic transfer of the impulse from the sensory nerve.

Muscle sensing and motor units. The studies of Elred (28) and Perl (64,65) lead to the association of the muscle spindles with facilitatory activity and to the association of Golgi tendon organs with facilitatory and inhibitory activity. While these processes may have no direct bearing on what happens with cutaneous stimulation, they do show to some extent the means by which the motor units operate in connection with these two reflex mechanisms and what must be taken into consideration in the assessment of causes of facilitation and inhibition. Further, of possible interest, Matthews (12) noted that the Golgi tendon organs do not go directly to the cortex but rather operate at the spinal level.

Paillard (63) reported that the reactivity of the motor neuron is known to be dependent to a great extent upon influences originating in muscle. This may be an important consideration when attempting to induce facilitation or inhibition by cutaneous stimulation of the skin over the muscle as in orthokinetic segment treatment.

Other studies as reported by Paillard on the effect of mechanical and electrical stimuli originating at the muscle have established the origin of some facilitatory discharges to be located in the muscle spindle and have also identified inhibitory effects originating from the Golgi tendon organ and from exteroceptors. These findings could be useful in supporting hypotheses about actual routes of impulse travel in cases of facilitation and inhibition prompted by orthokinetic segment treatments.

Currently, it can be generally postulated that the alpha sensory and motor neurons, the gamma sensory and motor neurons, and the Golgi tendon organ afferents operate at the spinal level for the reflex control of skeletal muscle. The gamma system provides a connection in some way with the sensory afferents from the skin. The alpha motor neurons may be thought of as existing in groups or pools ready to fire to serve the specific muscular needs of the organism, and gamma activity can perhaps increase the size of the pool available to a specific reflex by lowering the threshold of excitability. These postulates, based on anatomical and physiological research by Eldred (28,29) Hagbarth (37,29), Granit (33), and Matthews (12), and others provide the first good explanation of a plausible route by which Fuchs's and Blashy's orthokinetic segments may have so successfully taken effect.

Cutaneous stimulation. Eldred and Hagbarth (29) have shown that there are connections in the spinal cord which directly link the skin receptors and the effectors and proprioceptors of the muscle tissue directly under the skin area stimulated. But our knowledge of the sensory receptors is still so limited that we do not even know how they operate in apprizing the organism of such primitive environment states as heat and cold. Bouman (10) observed that, except for modalities theories, the interpretation of the sensation according to all other theories must occur at the spinal level; that is, that the same nerve must carry various sensations and that the sorting of the sensations is a spinal level activity.

Modern research seems on the verge of providing an explanation of the behavior of the receptors. The Weber-Fechner law of physics has been found to apply to nerves--the number of impulses in the sensory nerve is for practical purposes proportional to the logarithmic responses of the receptors (35). This law supports the idea that a step increase in sensation is proportional to a percentage increase in stimulus, thus giving strength to the idea that the character of sensation is actually determined by common peripheral sense organs rather than by specific ones.

There is yet another associated process, that in which the sense organs fire <u>after</u> a stimulus is removed; especially is this observable in the case where the organism is in a state of adaptation to the stimulus (33). Thus, the long-believed basic law of sense organ physiology that there are specific organs for responses to specific stimulating energies and that a particular sense organ will transmit only one particular sensation is now seriously questioned.

The Symposium on Cutaneous Sensitivity held in Fort Knox, Kentucky, in 1960 reported on recent exteroceptor studies. Kenshalo and Nafe (71) in the Symposium presented a theory that there is but one type of nerve termination at the skin which determines the qualitative differences between tactile and thermal sensations. They noted that the one thing that all stimuli have in common is some type of movement, and they concluded that the nerves must terminate in different tissues of the skin and that in this way differentiation in sensing can be accounted for. The Nafe theory says that tactile sensations are aroused by and during movement of various tissue. In thermal sensations, for example, the moving tissue involved is the smooth muscle composing the walls of the cutaneous arterioles.

In support of the Nafe theory, Jones (71) noted that in all these years, and especially recently with electronic equipment, not one sense modality has been proven, including the ones theorized for the eyes. He suggested that cutaneous sensory processes would be better likened to the sensations of thirst, nausea, and the biological urges--these being well defined feelings which can be correlated with temporal and spatial patterns of nerve discharge aroused by tissue movement.

Before concluding this limited look at cutaneous receptors, mention can be made of touch domes, which appear to be involved in tactile sensing, even though little is known about them as yet. They are slightly raised dome-shaped minute portions of the skin (180 to 300 microns in diameter, 80 to 100 microns high) which contain the terminals of nerves, and have been found on hairless prominences of skin in both cats and humans (70). There is some possibility that in the future they may provide clues in the puzzle of the sensory

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processes and that they may be functional in orthokinetic treatment.

Correlation of theories on cutaneous reception and on the operation of orthokinetic segments must await more research on both subjects. It can be postulated, however, from the evidence now present concerning the peripheral sense receptors that orthokinetic segments could give a varying dynamic effect depending on the arrangement of the elastic and inelastic fields.

Facilitatory and inhibitory skin areas for motor neurons. The recognition of the role of cutaneous stimulation in reflex behavior began with Sherrington and his co-workers at the turn of the century. They discovered that in the flexor reflex, cutaneous stimulation of the entire limb resulted in the contraction of the flexor muscles and the lengthening of the extensors (68). This process was thought to be excitation of the motor neurons of the flexors and inhibition of the motor neurons of the extensors. In 1903 Sherrington found an exception, the extensor thrust reflex (68). A low-intensity pressure on some skin areas, such as the foot pad, elicited a contraction of the extensor muscles.

During the first half of this century the topographical search for polarities in specific skin areas was set aside in order to make way for the search for modal nerve terminals sharing skin areas. The wide variation regularly found in responses to various stimulii seemed explainable only by the concept that on skin areas stimulation produced both excitatory and inhibitory reflexes but in most cases the stronger action of the former masked that of the latter. During this period "excitatory" was taken to mean normal impulse transmission over the reflex arc and inhibition was taken to mean the suppression of the normal ability of the motor neurons to transmit.

In 1947 Bernhard (9), with the aid of improved myographic and monosynaptic testing, showed that a single shock of a skin nerve excited an extensor muscle only after first inhibiting it. Hagbarth (37) had discovered that a continuous state of excitation could be maintained on an extensor muscle with a prolonged stimulation. These exceptions prompted Hagbarth to study the effects of cutaneous stimulation by specific skin areas and by the resultant excitatory-inhibitory effects on the motor neurons--techniques by this time having become available to measure the activity in the nerve itself. With these techniques Hagbarth was able to display on an oscilloscope the excitatory impulse in the motor neuron and also, more dramatically, to show excitation being reduced in the motor neuron of a muscle which was being subjected to reflex inhibition. Hagbarth applied various stimuli to all the skin areas of the limb, noting the excitatory and inhibiting effects. He found that all flexor muscles are to some degree excited by stimulation anywhere on the limb (Sherrington's rule) but that all muscles, including the extensors, are excited when the skin area directly over the muscle is stimulated. This last finding leads to the recognition of the complexity of reflex effects on a flexor muscle when the skin over its antagonistic extensor is stimulated: the flexor muscle is excited by the operation of the flexor reflex but is also inhibited by reflex inhibition due to the excitation of its antagonist by cutaneous stimulation over the latter. The resulting motor neuron activity of any muscle, Hagbarth concluded, is, therefore, the algebraic sum of the excitatory and inhibitory influences on it. The polarity of the skin areas for any muscle response can be described, according to Hagbarth, by the following statement: a flexor muscle is excited from most of the skin area of the limb and even to some extent from the skin area directly over its antagonistic extensor; an extensor muscle is inhibited from most of the skin area of the limb and is facilitated by the skin area directly over the muscle.

Hagbarth made an interesting observation about possible patterns in the way cutaneous stimulations operate. He observed (37) that, because strictly selective stimulation is difficult to obtain, it is not possible to eliminate the idea that inhibitory spinal connections from a skin area may exist. He concluded: "If, for instance, in one way or another the dominating effects from an excitatory skin area are blocked or sufficiently suppressed, then concealed inhibition may become manifest."

The research above was conducted on alpha fibers exclusively and was concerned with direct-route (_i.e._, reflex) excitation and with postsynaptic (_i.e._, reflex) inhibition.

Eldred and Hagbarth (29) studied the gamma loop with basically the same experimental design. The skin alpha fibers were stimulated and the gamma loop was observed. They discovered that changes in the gamma loop may precede activity in the alpha motor neuron fibers. The increased or decreased alpha motor neuron activity following and affected by such gamma activity must be described differently from that following alpha stimulation alone. This research on gamma fibers introduces with experimental basis the idea of facilitation--a concept which implies presynaptic and postsynaptic preparation for greater motor neuron activity. Such facilitation and its running mate, presynaptic inhibition, are of great interest to orthokinetic investigators because they give promise of proving to be the mechanisms by which orthokinetic effects take place. Only very recently have research reports begun to appear on these specific subjects. It is Blashy's opinion (6) that continuation of the type of research done by Hagbarth and his associates will result in the identification of the anatomical parts and processes by which orthokinetic effects take place.

Inhibitory processes. The general nature of motility in organisms demands that some muscles be stimulated to contract and some muscles be inhibited from doing so. The study of the inhibitory process has proceeded independently in many cases. It is interesting to note that the autonomic nervous system is known to have some specific long-fibered neurons whose purpose is inhibition (24). This specificity has not been found in the voluntary system. It is clear, however, that inhibition occurs in the voluntary system; therefore, it is postulated that there are interneurons completely contained within the spinal cord whose functions are to inhibit (24,28). Hagbarth's study in 1952 (37) not only showed the ability of cutaneous stimulation to excite a muscle response in extensors as well as flexors but also demonstrated quantitatively the inhibition process. In their study on the gamma loop Eldred and Hagbarth (29) introduced new concepts of facilitation, and their work enabled the inference of presynaptic inhibition.

The process of presynaptic inhibition is especially useful to an explanation of one manner in which orthokinetic effect could be found to take place. If the effect of the segments can reach the central nervous system, then presynaptic inhibition is a known process by which muscle facilitation and inhibition could be achieved. The segments could achieve inhibition presynaptically, so far as may be surmised at this time, by involving the gamma loop from the skin afferents, by conditioning the motor units in some way such as by an impulse from the skin which produces an inhibitory state as a secondary effect, and by involvement through cutaneous stimuli of the higher centers which could increase the inhibitory background activity; and finally it is not proven impossible to inhibit presynaptically direct from the skin.

The segments also might inhibit postsynaptically in several ways already known, assuming that they initiate their affect somehow through the skin sensory receptors; namely, by reflex mechanisms using interneurons, by involvement of the gamma loop, and/or by involvement of Renshaw cells which are part of recurrent motor neuron circuits. Also, it still remains feasible that different kinds of synaptic action may yet be discovered to explain any behavior of the organism that could be observed in a gross fashion.

In the literature on orthokinetics, as well as on the neurophysiology and neuroanatomy related to it, there is as yet no point-by-point means by which orthokinetic processes can be definitely explained. On the other hand it is also significant that given the most recent research with sophisticated surgical and electronic techniques nothing has been unearthed which decidedly disfavors the possibilities of orthokinetic effect.

Fuchs spoke of the segments as "transferring the power" of one muscle under a segment field to another muscle under an associated segment field. This, of course, seems highly unlikely from a scientific point of view. What is more likely is that by their effect on the skin the segments facilitate or inhibit various parts of the central nervous system so that other stimuli have greater effect.

Neuromuscular facilitation and inhibition in physical therapy. Facilitation, and to some extent inhibition, also has come to be known from the work of applied therapists (8,21,39,41,54).

Kabat (55) gave a review of techniques which have been used successfully at the Kabat-Kaiser Institute on thousands of patients who suffered from muscular dysfunction. His term "maximal resistance" is the technique of requiring a weak or dysfunctioning muscle to perform a maximal task with the aid of the synergistic muscles. "Stretch" is a technique which uses the myotatic reflex in which the belly of the muscle to be worked is struck lightly and sharply, thereby stretching the spindles. The stretching of a dysfunctioning muscle before it is required to work facilitates its own action; still another stretch technique is the stretching of related muscles used in the same mass movements as the dysfunctioning muscle. "Mass movement patterns" is the term for the technique of moving body segments in spiral-diagonal patterns in which the nervous connections have low synaptic resistance--these are the kinds of movements used in sports, such as throwing a ball or paddling a canoe. The various "reflex" techniques utilize various methods of triggering the reflex, such as pressure to proprioceptive organs at the belly and at the origin of muscles, cutaneous stimulation to elicit the flexor reflex, pressure on extremities to elicit the extensor thrust reflex, manipulation of the head to utilize the tonic neck reflex, positioning the whole body with respect to gravity to involve the righting reflexes. All these techniques have been shown clinically to bring central facilitation to bear.

As to the empirical evidences and uses of central facilitation two recent therapeutic techniques would seem to have much in common with an orthokinetic technique. Light brushing of the skin over a muscle to be moved is a treatment which has a facilitatory effect (21). Perhaps the explanation of the facilitation is that ultimately the gamma efferents to the muscle spindle are stimulated, and in turn they lower the threshold of excitability of the motor pool. Perhaps orthokinetic treatment, if found to have predictable effects, operates via the same pathway. It is not too much for the imagination to equate as stimuli brushing and the light touch of an elastic wrapping device. The technique of ice application is another skin treatment. It has been demonstrated clinically (21) that ice rubbed or applied on the skin first inhibits the muscle response and then facilitates it. The causes of these results are unknown, but the use of the cutaneous stimulus and the reversal of the effect make of it an item for mention in research related to orthokinetics.

Therapeutic work in general aims at promoting muscle movement and thus has an inherent bias in that it tends to seek out facilitatory techniques. Inhibition has been brought forward mainly by the surgical and microanatomical investigators. A few techniques involving inhibition, however, seem to be in general use by therapists (7,8,21), but they are definitely secondary to facilitatory techniques.

Several recent studies show that much more research in the area of central facilitation must be done before definitive statements can be made. Kraus and Matthews (53) conducted a study in which they commented on the necessity for careful experimental design, and especially they recommended having a large number of subjects for high statistical reliability. They could not find cross-transfer of strength in bilateral and unilateral isotonic exercise. Cross-transfer as used by them is synonymous with Hellebrandt's (42) central facilitation. In 1965 Kroll (49) also found no central facilitation when he conducted a series of investigations seeking the relationship of isometric contractions to it. Kroll (50) again used isometric wrist contractions to investigate the possibility of cross-transfer effects and again found no evidence of central facilitation.

Acupuncture. Research which involves techniques which are in every aspect very new and for which the scientific explanations are far from patent should include reports of any investigations which may possibly have a bearing, regardless of esoteric characteristics. The Chinese system of acupuncture is a method of treating internal symptoms by the insertion of fine needles at certain points slightly under the skin (46). There are some scientific supports for this treatment (1,59,70) but generally it may be noted that it has been in use for thousands of years--a fact which in itself gives a fair amount of empirical weight to the concept of the existence of some form of direct skin-to-organ connection. In the final analysis, therefore, it is not even possible to rule out the literal aspects of a statement by Fuchs (32) that the segments "transfer the power"; that is, it is not scientifically permissible to unequivocally state that the segments could not by some means transfer some kind of impulse around the limb by way of the skin without recourse to what is normally considered the central nervous system.

METHODOLOGY

Subjects. One hundred and two volunteers were selected as subjects by chance techniques from among the male students registering for required physical education classes. This large number was used to ensure finishing the experiment with at least eighteen subjects per group. No size or performance criteria were imposed in the selection process, but all subjects were free of physical disabilities and had a health grade of A (the highest rating). Their ages were 18 to 23 years. In the experiment the subjects wore tennis shoes and gym shorts.

Equipment. The equipment used for the vertical jump consisted of a hard foam-rubber take-off mat and an adjustable black touch board ruled with white lines. The subjects used gymnastic chalk on their finger tips to mark the board when they jumped. For the standing broad jump the take-off board was raised two inches and was braced against the cement wall to prevent its movement. The subjects rubbed the soles of their shoes in powdered resin before each jump to ensure good footing. The landing mat of hard foam-rubber extended twenty feet from the take-off board and was marked with a black scale. All jumps were measured to the last half inch. The two stationary exercise bicycles used were of the typical one-wheel friction-load design made especially for stationary exercising, and for this experiment the load was set for mild work.

The orthokinetic segments (Figure 2) were constructed according to specifications made for this writer by Dr. M. R. M. Blashy during an interview at his hospital office in Temple, Texas, in January 1966. Six-inch elastic bandaging material was made up in three layers to form the elastic portion, and the inelastic portion was made up of two layers of six-inch elastic bandaging stitched together with a six-inch nonelastic piece of eight-ounce canvas between. The lengths of the portions were such that when sewn together consecutively they completely enveloped the thigh and such that the area of the elastic field was approximately ten per cent greater than the area of the inelastic field. The fastening and adjusting device was that kind of nylon hooks-and-loops fastener commonly known as nylon non-zipper fastener or "ValCro." For correct fitting of different thigh sizes the segments were made to specifications in five lengths--18 inches, 20 inches, 22 inches, 23 inches, 25 inches.

The correct wearing of the segments was an important element in the study. The investigator personally checked the placement of the orthokinetic segments each day on each subject in order to ensure 1) that the appropriate elastic or inelastic field was squarely over the muscle mass, and 2) that the tightness was correct--namely, that the pressure

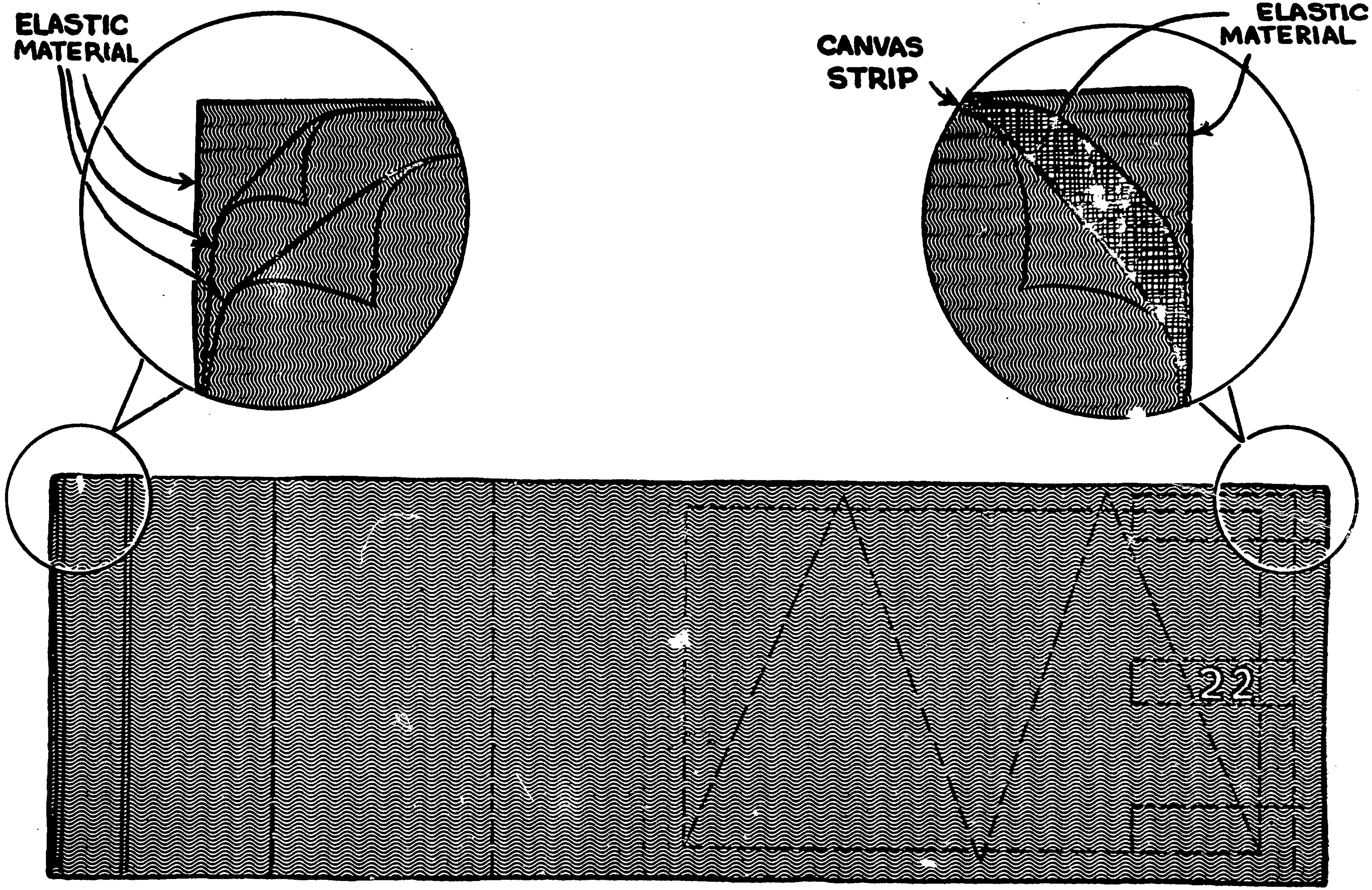

Figure 2. AN ORTHOKINETIC SEGMENT

was as light as possible while still keeping the segments from sliding down the leg.

Criterion measures, exercise, and rest. The standing broad jump and the vertical jump were chosen as the criterion measures for several reasons. A pilot study gave indications that a measure of explosive strength would reflect segment effect more than, for example, reaction time tests or reflex time tests. The pilot study indicated that static strength would be a good measure, but explosive strengths was further selected because it is a more pertinent factor in motor performance--where orthokinetics will be most likely applied--and because the researches of Kroll (49,50) failed to find central facilitation when the exercising and testing was done with isometric contractions. Furthermore, Nicks and Fleischman (62) have identified explosive strength as the most frequently appearing factor associated with good physical fitness in their factor analytic studies of physical fitness tests, and have further found that among the tests which adequately measure the factor of explosive strength the standing broad jump and the vertical jump appeared to be the best.

Stationary bicycling in the amount of one five-minute bout was selected as the exercise for the one group which exercised prior to testing because it was recommended by Blashy during the interview. Blashy felt that rotary exercise should result in a more pronounced effect in subsequent orthokinetic treatment. A three-minute minimum was established as the interval between jumps, and a five-minute minimum was required after the bicycle exercise and before the first jump in order to ensure that the subjects were not fatigued. The subjects continued to wear segments during all rest intervals. The order of jumping and resting for each subject was as follows: vertical jump, at least three minutes' rest, standing broad jump, at least three minutes' rest, vertical jump, and so forth until the required number of five jumps of each type was attained.

General procedures. Subjects and assistants were kept naive in all respects concerning the aims of the experiment and the purpose or functioning of the segments. Incentive was sought to be regulated by reading the same written instructions to all subjects and by the investigator speaking as little as possible, using the same spoken words with all groups; also, the number of jumps per student (five of each type each day) was designed to regulate incentive.

Four subject groups were needed as determined by the theoretical propositions and by the analytical methods selected to test them. There were one control group and three treatment groups, A, B, and C. The testing period of eight weeks was made up of three consecutive phases: Phase I of three weeks, Phase II of three weeks, and Phase III of two weeks. These lengths of time were chosen to ensure enough time for gaining sufficient data. As a matter of convenience and to establish a general regularity the testing sessions were held on consecutive Monday, Wednesday, and Friday mornings.

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<u>Experimental Design</u>. The design chosen for the treatment disposition of the groups was typical of Lindquist's Type I format (56) in which the subjects performed under more than one but not in all of the conditions, except for the control group which performed in only one condition. Each of the A treatments in combination with any one B treatment is given to the same subjects but with each B treatment given to a different group of subjects, except for the control group which is given the same A treatment (normal) in order to serve as a standard.

The experimental design called for the control group to jump without segments throughout the entire period. Groups A, B, and C wore the segments in different ways in the different phases as scheduled in Figure 3.

Group	Phase I (three weeks)	Phase II (three weeks)	Phase III (two weeks)
A	Inhibition with rotary exercise	Facilitation with rotary exercise	Normal with rotary exercise
B	Facilitation	Inhibition	Normal
C	Inhibition	Facilitation	Normal
Control	Normal	Normal	Normal

FIGURE 3. Disposition of groups by experiment phase.

With regard to Blashy's (5) specifications, when the placing method was facilitatory, the elastic fields of the segments were worn over the anterior portion of the thighs (centered over the Quadriceps Femoris) with the inelastic fields covering the posterior hamstring groups. When the placing was inhibitory, the fields were reversed. The subjects wore segments on both legs. "Normal" means that no segments were worn.

Representative measure and missing data procedures. The experimental design called for each subject to jump five times each day on each of the criterion measures. What had to be determined was the single measure that best represented the daily trials for each criterion measure. An analysis of randomly selected daily trials resulted in the decision to use the arithmetic mean of the daily five measures as a criterion measure. Considerations of reliability analysis and theory support this choice (51).

Due to illness and other unavoidable circumstances a few of the subjects were absent occasionally during the experiment, and in these instances the missing data had to be estimated. Winer (74) recommends the formula:

$$\overline{AB}_{ij} = \overline{A}_1 + \overline{B}_1 - \overline{G},$$

which formula was here selected because it results in the least effect on both the within variance and the between variance. Each time this technique was applied to fill in a cell where a datum was missing one degree of freedom was subtracted from the appropriate degrees of freedom associated with the mean square between individual trends.

Percision and sample size. In planning this study, attention was given to the demonstration of statistical significance when differences of practical significance were present. The design of the experiment involved double classification analysis of variance, and a pilot study--using the standing broad jump--allowed an estimate of anticipated error terms for individual trial contrasts. Based on such estimates the number of subjects to be employed in the present study was determined so as to provide precision sufficient to demonstrate statistical significance for trial contrasts in the order of five percent or above of mean criterion measures.

The sample size was determined by following the procedures described by Winer (74); the minimum number of subjects per group was formulated at twelve. By starting with groups of twenty-five and twenty-six the meeting of the statistical minimum was ensured; practically ensured as well was the meeting of a conservatively set minimum of eighteen. In the experiment the latter minimum was achieved, giving considerable confidence, therefore, in the final sample size.

With the chance selection of subjects from the specified population and with random assignment procedures, there was no reason to doubt that basic assumptions of normality and homogeneity were not met. It was assumed, therefore, that errors of measurement were normally distributed and that several such distributions would have homogeneous variances. If there had been a significant between group means F, it could have been said that the differences were in the means of the various treatment populations.

<u>Analysis</u>. The data for this study were analyzed with the aid of high-speed computers. The analytical task was to determine if there were significant differences in the motor responses of the groups under the different treatment conditions. A significance level of one percent for rejection of null hypotheses was decided upon to ensure the meaningfulness of this study in terms of basic physiological research.

The data were analyzed by an analysis of variance of trends, as suggested by Grant (34). The analysis involved the use of orthogonal polynomials and allowed statistical tests to be made for the determination of the best fitting curve for main effects over trials for all four groups, as well as trend differences between groups representing the different treatments. Trend tests to the quartic degree were performed. In this study the data of the standing broad jump and the vertical jump were analyzed independently. The same procedures were used for each as described here: For each criterion measure Grant's method was used for the data as a whole; <u>i.e.</u>, the means of all experimental days were used for an overall analysis. Then his method was used to analyze the data of each phase. Finally, paired analyses of the interaction of the trends of the individual experimental groups were made of the data of Phase I. The procedure was to determine significant trend components by trend analysis for two groups at a time. All groups were paired in each criterion measure.

RESULTS

Analysis of the vertical jump mean scores. A graph of the vertical jump mean scores is presented in Figure 4. Inspection of the graph indicates that the mean scores of the groups with orthokinetic segments are greater than those of the untreated control group, but, as the analysis of variance which follows will show, there is not enough difference for significance at the one percent level. The graph indicates that little, if any, improvement took place in the control group during the experiment.

Tables I through IV present the analysis of variance for the total period and the various phases. While the significant overall trend F of 12.109 (Table I) for the total twenty-four day period indicates that there is a significant trend for the vertical jump scores over trials, this is not a useful factor in this experiment as designed. The between group trends F of 2.975 for the total period indicates that there are significant differences in trends between groups representing different treatment conditions. This significance joined in prompting the paired analysis of Phase I, reported below. The significant F of 6.603 for the linear component of between group trends indicates that there is a significant difference in the linear trend between at least

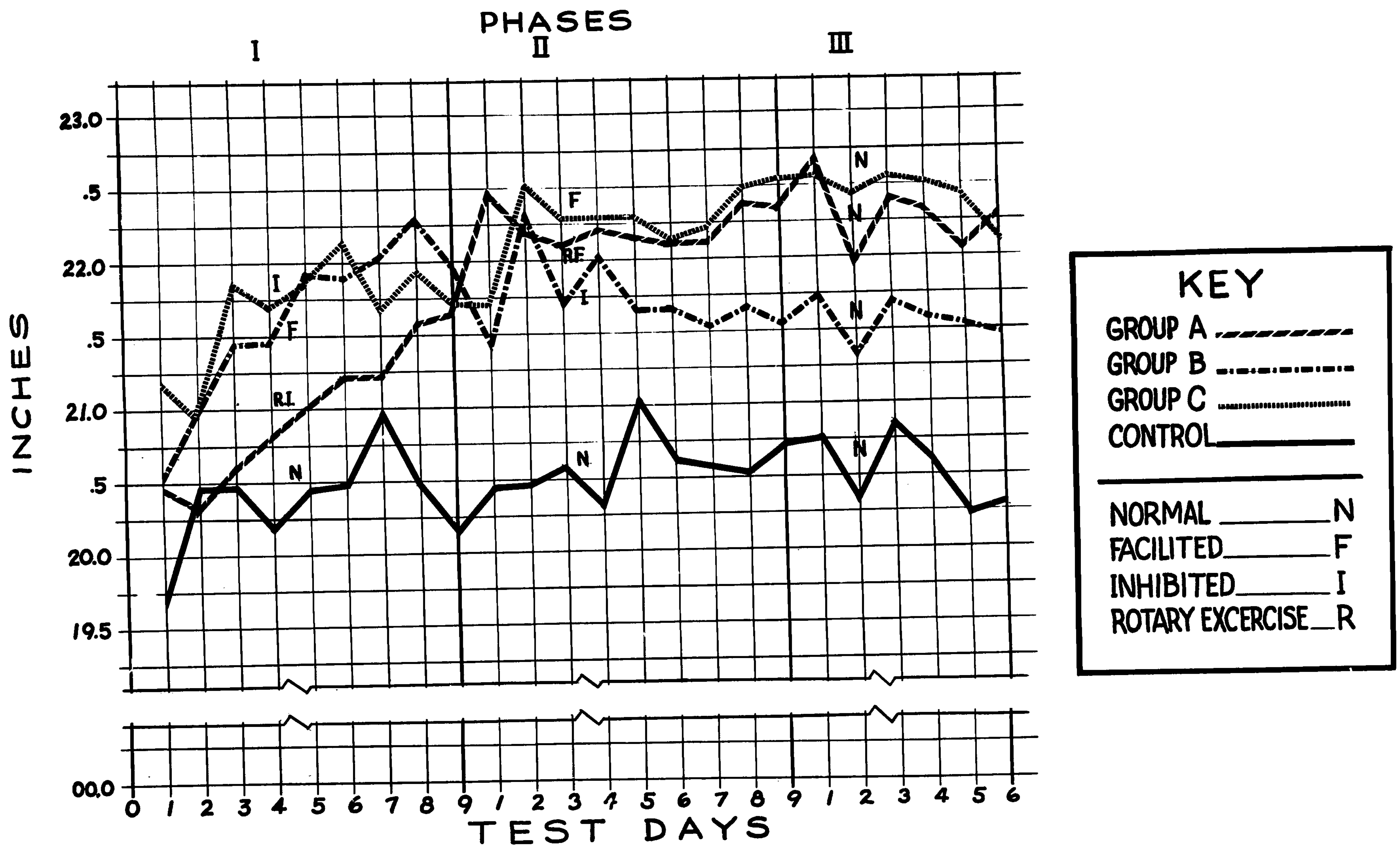

Figure 4. Comparisons of Vertical Jump Score Means for the Four Treatment Groups over All Phases

TABLE I

ANALYSIS OF VARIANCE OF TRENDS OF THE VERTICAL JUMP SCORE MEANS FOR THE FOUR TREATMENT GROUPS OVER TWENTY-FOUR TEST DAYS

Source	MS	DF	F	P
Overall trend	9.927	23	12.109	.01
Linear	116.400	1	27.422	.01
Quadratic	78.307	1	55.673	.01
Cubic	5.749	1	4.929	.01
Quartic	3.104	1	3.704	.05
Between group means	236.336	3	1.921	NS
Between group trends	2.433	69	2.975	.01
Linear	28.031	3	6.603	.01
Quadratic	3.817	3	2.714	NS
Cubic	4.867	3	4.173	NS
Quartic	2.873	3	3.428	NS
Between individual means	123.020	68		
Between individual trends	.820	1438*		
Linear	4.245	68		
Quadratic	1.407	68		
Cubic	1.166	68		
Quartic	.838	68		
Total	6.606	1601*		

* 126 degrees of freedom were subtracted from between individual trends and total because of missing scores.

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TABLE II

ANALYSIS OF VARIANCE OF TRENDS OF THE VERTICAL JUMP SCORE MEANS FOR THE FOUR TREATMENT GROUPS OVER THE FIRST NINE TEST DAYS (PHASE I)

Source	MS	DF	F	P
Overall trend	10.947	8	16.846	.01
Linear	70.712	1	44.724	.01
Quadratic	13.333	1	19.782	.01
Cubic	1.087	1	2.364	NS
Quartic	.307	1	.517	NS
Between group means	68.765	3	1.442	NS
Between group trends	1.428	24	2.195	.01
Linear	4.786	3	3.027	.05
Quadratic	1.617	3	2.399	NS
Cubic	.053	3	.114	NS
Quartic	2.216	3	3.730	.05
Between individual means	47.700	68		
Between individual trends	.651	506*		
Linear	1.581	68		
Quadratic	.674	68		
Cubic	.460	68		
Quartic	.594	68		
Total	6.422	609*		

* 38 degrees of freedom were subtracted from between individual trends and total because of missing scores.

TABLE III

ANALYSIS OF VARIANCE OF TRENDS OF THE VERTICAL JUMP SCORE MEANS FOR THE FOUR TREATMENT GROUPS OVER THE SECOND NINE TEST DAYS (PHASE II)

Source	MS	DF	F	P
Overall trend	.920	8	1.672	NS
Linear	.122	1	.139	NS
Quadratic	.474	1	.750	NS
Cubic	2.594	1	4.879	.01
Quartic	.293	1	.719	NS
Between group means	111.754	3	2.378	NS
Between group trends	.906	24	1.636	.01
Linear	.916	3	1.042	NS
Quadratic	1.262	3	1.998	NS
Cubic	1.222	3	2.298	NS
Quartic	1.448	3	3.552	.05
Between individual means	46.997	68		
Between individual trends	.553	488*		
Linear	.879	68		
Quadratic	.632	68		
Cubic	.532	68		
Quartic	.408	68		
Total	6.471	591*		

* 56 degrees of freedom were subtracted from between individual trends and total because of missing scores.

TABLE IV

ANALYSIS OF VARIANCE OF TRENDS OF THE VERTICAL JUMP SCORE MEANS FOR THE FOUR TREATMENT GROUPS OVER THE LAST SIX TEST DAYS (PHASE III)

Source	MS	DF	F	P
Overall trend	2.785	5	6.340	.01
Linear	2.777	1	5.544	.01
Quadratic	.149	1	.409	NS
Cubic	1.618	1	4.198	.01
Quartic	8.000	1	27.593	.01
Between group means	91.346	3	2.714	NS
Between group trends	.353	15	.802	NS
Linear	.276	3	.551	NS
Quadratic	.628	3	1.726	NS
Cubic	.140	3	.362	NS
Quartic	.648	3	2.234	NS
Between individual means	33.657	68		
Between individual trends	.440	308*		
Linear	.501	68		
Quadratic	.364	68		
Cubic	.385	68		
Quartic	.290	68		
Total	6.816	399*		

* 32 degrees of freedom were subtracted from between individual trends and total because of missing scores.

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two of these groups, but again this result is not useful. The significant overall trend F of 16.846 (Table II) for the first nine test days is a significant trend for the vertical jump scores over trials in Phase I. The total variance comprising the overall trend in Phase I is represented by a sum of squares equal to 87.576 (mean square of 10.947 times the degrees of freedom of 8). The linear trend component accounted for 80.7 percent of the overall trend variance (70.712/87.576). The overall trend quadratic component was also significant accounting for an additional 12.5 percent (13.333/87.576). Thus, the quadratic trend component accounted for 95.9 percent of the total overall trend variance. The presence of a strong quadratic trend component accounting for some 95.5 percent of the total overall trend variance during Phase I was not unexpected. Learning curves for gross motor skills usually demonstrate a fast initial rise followed by a general plateau. Hence, a strong quadratic trend for vertical jump performance was not atypical. For comparative analysis this result is not directly useful. It does join, however, in prompting the paired analysis of groups in Phase I to attempt to isolate interactions which may be masked by the overall analysis.

Although there is a significant between group trends F of 2.195 (Table II), neither the linear (F = 3.027) nor the quadratic (F = 2.399) between group trend components was significant at the .01 level. Since neither the between group means F of 1.442 nor the linear and quadratic between group trend components reached the level required for significance, it seems clear the results do not demonstrate the presence of any orthokinetic segment effects upon performance in the vertical jump during Phase I. The between group trends F, nevertheless, also joined in prompting a closer analysis of the groups in Phase I by pairing them in an analysis of variance.

During Phase II (Table III) a complete plateau of vertical jump performance resulted. Neither the overall trend nor the between group means F ratio was significant. As in Phase I, no effects upon performance in the vertical jump due to orthokinetic segments were demonstrated at the required level of significance in a useful analysis. The results of the analyses of Phase III (Table IV) were not useful.

A separate trend analysis was made for each of the possible pairings of the treatment groups in the vertical jump in Phase I. The purpose of these analyses was to isolate the source of the significant between group trends F-ratio. Interest was upon meaningful identification of trend differences between treatment groups as possible indicators of orthokinetic segment effects upon performance. Even though the F-ratio for between group means indicated no significant differences between treatment groups on mean performance levels, the possibility existed that differences in group trends (or patterns) of performance might reveal the presence of orthokinetic segment effects. A similar analysis was made of any phase where the F-ratio was significant and where the source of the significant interaction for trends existed on linear, quadratic or cubic trend components. The tables of these paired analyses have not been presented because of their very limited meaning and usefulness; significances which appeared are duly noted below.

The rationale for attention to between paired group trend differences was based on the possibility that orthokinetic segments might not effect greater maximum performance levels but could effect a faster achievement of maximum performance. Faster achievement of maximum performance might be reflected in between group trend differences even though the between group means F-ratio was nonsignificant. Needless to say, faster acquisition of maximum performance levels would be a valuable effect even if no significant differences in maximum performance levels resulted. If, for example, orthokinetic segments could effect achievement of maximum performance several days earlier than without their use, a considerable savings in time necessary for practice and/or training would be realized.

The separate trend analyses for each of the possible pairings of treatment groups during Phase I demonstrated only one significant difference in between group trends F-ratios. When the control group was compared with the facilitated group, significant differences in linear and quadratic trend components resulted. None of the between groups means F-ratios was significant. Although based upon rather slim evidence, it is conceivable that longer exposure to orthokinetic segments might have resulted in a demonstrable (statistically significant) difference in mean performance levels on the vertical jump for the control and facilitated experimental groups during Phase I.

Based strictly upon statistical results and taken as a whole, however, analysis of the vertical jump data suggests no evidence of orthokinetic segment effects, either facilitatory or inhibitory. Between group means F-ratios for each of the three treatment phases as well as for the total twenty-four day experimental period were nonsignificant. Although the between group trends F-ratio for Phase I was significant, separate trend analyses for each of the possible pairings of treatment groups identified only one meaningful difference in trend components (between the control and facilitated groups). No significant between group means F-ratio resulted for any contrast made.

Analysis of standing broad jump mean scores. A graph of the standing broad jump mean scores is presented in Figure 5. Inspection of the graph indicates that the mean scores of the groups treated with orthokinetic segments are greater than those of the untreated control group, but as the analysis of variance which follows will show, the differences were not significant at the one percent level. Of some interest is the apparent decline in standing broad jump performance for groups A and C, both of which performed with orthokinetic segments in place to inhibit jumping performance. After an initial rise

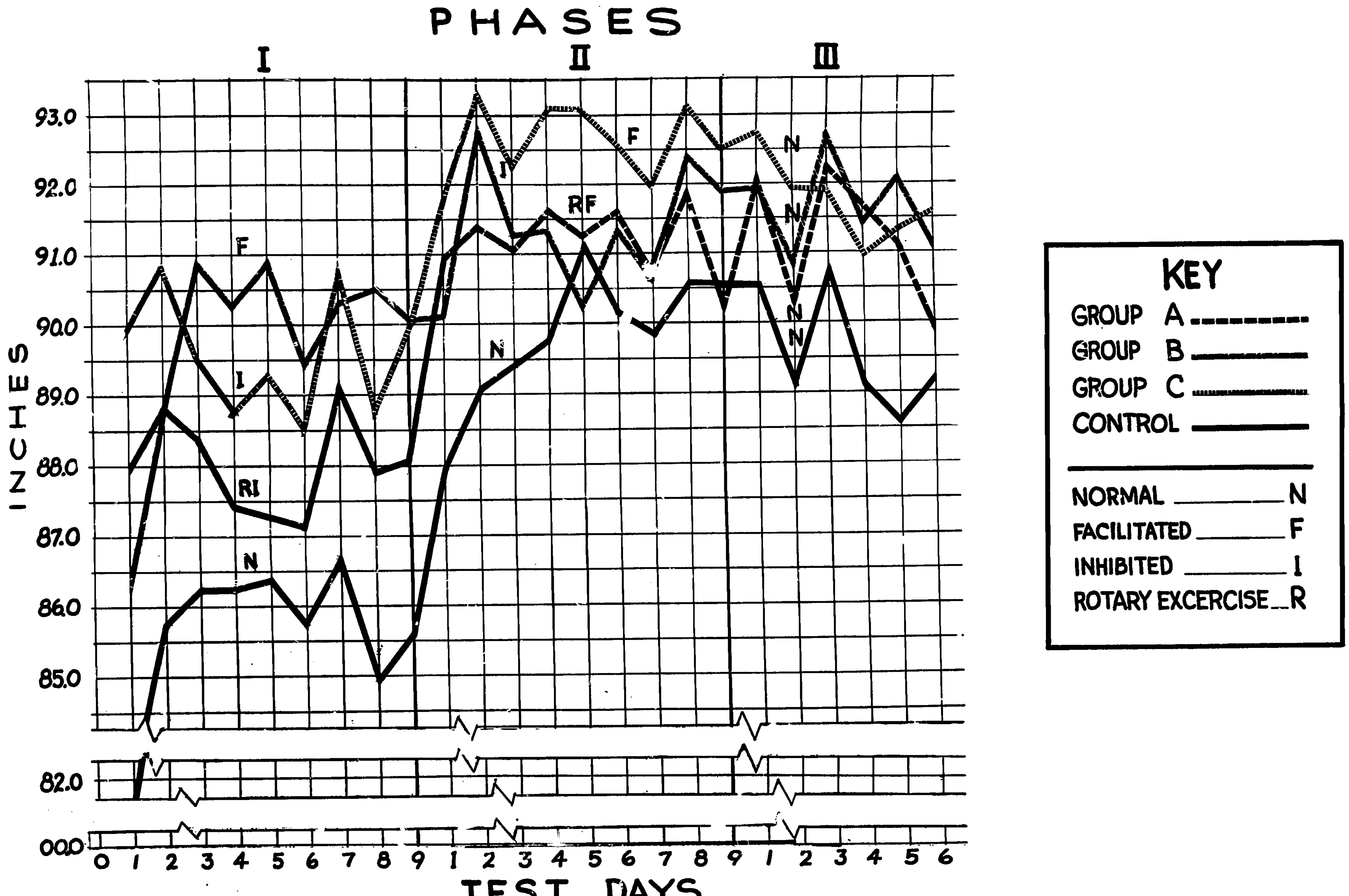

Figure 5. Comparisons of Standing Broad Jump Score Means for the Four Treatment Groups over All Phases

on day 2, performance fell during days 3, 4, 5, and 6 and then rose once again on day 7. Group B, with segments in place to facilitate jumping performance, made a quick rise in performance on days 2 and 3 only to generally plateau for the remainder of Phase I.

Tables V through VIII presents the analysis of variance for the total period and the various phases. As in the vertical jump, the analyses of the overall period and of Phases II and III of the standing broad jump mean scores produced no useful results. In Phase I however, there was some justification for analysis of the groups by pairs as was done in the vertical jump. Further, this paired analysis could be compared with the similar pairings in the vertical jump.

The significant F of 5.292 (Table VI) for the quadratic component of between group trends in Phase I indicates that there is a significant difference in quadratic trend between at least two of these groups. Unlike the overall trend of Phase I for the vertical jump performance, the standing broad jump performance trend failed to demonstrate a significant linear component. In addition, the cubic trend component was present with some significance in the standing broad jump performance. Apparently, the standing broad jump represents a motor task demanding greater adaptation and modification in skill acquisition than the vertical jump.

Since the F-ratio for between group trends was significant for Phase I and the source of the significant interaction for group trends existed in a meaningful trend com-

TABLE V

ANALYSIS OF VARIANCE OF TRENDS OF THE STANDING BROAD JUMP SCORE MEANS FOR THE FOUR TREATMENT GROUPS OVER TWENTY-FOUR TEST DAYS

Source	MS	DF	F	P
Overall trend	187.627	23	20.810	.01
Linear	2525.488	1	57.921	.01
Quadratic	676.285	1	29.758	.01
Cubic	198.815	1	13.535	.01
Quartic	15.086	1	1.060	NS
Between group means	818.782	3	.639	NS
Between group trends	15.948	69	1.676	.01
Linear	99.551	3	2.283	NS
Quadratic	25.520	3	1.123	NS
Cubic	51.656	3	3.517	.05
Quartic	64.041	3	4.499	.01
Between individual means	1281.106	68		
Between individual trends	9.461	1438*		
Linear	43.603	68		
Quadratic	22.726	68		
Cubic	14.688	68		
Quartic	14.232	68		
Total	67.238	1601*		

* 126 degrees of freedom were subtracted from between individual trends and total because of missing scores.

TABLE VI

ANALYSIS OF VARIANCE OF TRENDS OF THE STANDING BROAD JUMP SCORE MEANS FOR THE FOUR TREATMENT GROUPS OVER THE FIRST NINE TEST DAYS (PHASE I)

Source	MS	DF	F	P
Overall trend	48.655	8	5.794	.01
Linear	42.305	1	2.565	NS
Quadratic	64.004	1	4.814	.01
Cubic	79.768	1	11.949	.01
Quartic	78.597	1	9.139	.01
Between group means	656.083	3	1.493	NS
Between group trends	16.914	24	2.014	.01
Linear	29.628	3	1.796	NS
Quadratic	70.355	3	5.292	.01
Cubic	19.513	3	2.923	.05
Quartic	1.101	3	.128	NS
Between individual means	439.321	68		
Between individual trends	8.428	506*		
Linear	16.493	68		
Quadratic	13.294	68		
Cubic	6.675	68		
Quartic	8.599	68		
Total	80.367	609*		

* 38 degrees of freedom were subtracted from between individual trends and total because of missing scores.

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TABLE VII

ANALYSIS OF VARIANCE OF TRENDS OF THE STANDING BROAD JUMP SCORE MEANS FOR THE FOUR TREATMENT GROUPS OVER THE SECOND NINE TEST DAYS (PHASE II)

Source	MS	DF	F	P
Overall trend	17.979	8	2.986	.01
Linear	31.758	1	2.924	.05
Quadratic	13.143	1	2.272	NS
Cubic	14.939	1	2.686	NS
Quartic	16.751	1	2.990	.05
Between group means	209.013	3	.405	NS
Between group trends	6.597	24	1.095	NS
Linear	16.650	3	1.533	NS
Quadratic	7.136	3	1.233	NS
Cubic	4.723	3	.849	NS
Quartic	12.777	3	2.281	NS
Between individual means	515.614	68		
Between individual trends	6.019	488*		
Linear	10.861	68		
Quadratic	5.785	68		
Cubic	5.561	68		
Quartic	5.602	68		
Total	65.024	591*		

* 56 degrees of freedom were subtracted from between individual trends and total because of missing scores.

TABLE VIII

ANALYSIS OF VARIANCE OF TRENDS OF THE STANDING BROAD JUMP SCORE MEANS FOR THE FOUR TREATMENT GROUPS OVER THE LAST SIX TEST DAYS (PHASE III)

Source	MS	DF	F	P
Overall trend	34.546	5	5.572	.01
Linear	58.243	1	11.884	.01
Quadratic	.006	1	.001	NS
Cubic	3.527	1	.602	NS
Quartic	39.727	1	6.845	.01
Between group means	101.777	3	.259	NS
Between group trends	6.123	15	1.098	NS
Linear	3.771	3	.769	NS
Quadratic	9.554	3	1.691	NS
Cubic	6.423	3	1.095	NS
Quartic	4.145	3	.714	NS
Between individual means	392.130	68		
Between individual trends	6.203	308*		
Linear	4.901	68		
Quadratic	5.650	68		
Cubic	5.864	68		
Quartic	5.803	68		
Total	73.055	399*		

* 32 degrees of freedom were subtracted from between individual trends and total because of missing scores.

ponent (quadratic), separate trend analyses were made for each of the possible pairings of treatment groups. As previously noted, even though the F-ratio for between group means indicated no significant differences between mean performance levels, the possibility existed that differences in group trends of performance might reveal the presence of orthokinetic segment effects.

Unlike results on the vertical jump, the separate trend analyses demonstrated no significant differences in between group trends when the control and facilitated groups were compared. Thus, possible evidence of orthokinetic segment effects suggested by between group trends differences for control and facilitated groups in Phase I of the vertical jump was not corroborated with a similar result on the standing broad jump data.

During Phase I of the standing broad jump, however, between group trends F-ratios in the paired group trend analyses did suggest a possible inhibitory effect of orthokinetic segments upon performance. Both the inhibited group and the rotary exercise inhibited group differed from the control group on the quadratic between groups trend component. The facilitated group differed significantly from the rotary exercise inhibited group on the quadratic between groups trend component as well. As can be seen in Figure 5, the direction of these differences in trend performances is such to suggest a possible inhibitory effect of orthokinetic segments upon standing broad jump during Phase I. As in the vertical jump analyses, however, none of

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the between group means F-ratios were significant.

Based strictly upon statistical results and taken as a whole, the standing broad jump analysis parallels results for the vertical jump: 1) between group means F-ratios for each of the treatment phases as well as for the total twenty-four day experimental period were nonsignificant indicating no significant differences in mean performance levels; and 2) separate trend analyses for each of the possible pairings of treatment groups when a significant between group trends F was present identified no meaningful differences in trend components that were coupled with a significant between group means F-ratio. No sound evidence resulted suggesting orthokinetic segment effects upon standing broad jump measures.

DISCUSSION

According to orthokinetic theory, when the elastic portion of an orthokinetic segment is placed over a muscle it should facilitate action of that muscle, and when the inelastic portion of an orthokinetic segment is placed over a muscle it should inhibit action of the muscle. Orthokinetic segments were constructed such that whenever the elastic field was over the Quadriceps Femoris the inelastic field was over its antagonist, the hamstring muscle group. Two effects, therefore, were theoretically operating on any standing broad jump or vertical jump: the elastic field should have improved the jump by facilitating the prime mover under it, and the inelastic field should also have improved the jumping performance due to its

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inhibitory action upon the antagonistic muscle. Conversely, when orthokinetic segments were reversed a poorer performance in jumping should have resulted.

Based upon such a state of affairs, the wearing of orthokinetic segments should have affected the magnitude of jumping performance in the following manner:

1. An increased magnitude of jumping performance should have resulted whenever the elastic field of an orthokinetic segment was over the prime mover and the inelastic field over the antagonist; and

2. A decreased magnitude of jumping performance should have occurred when the orthokinetic segments were reversed, placing the inelastic field over the prime mover and the elastic field over the antagonist.

The interpretations of the findings of both criterion measures are the same in that the specific effects of the various facilitatory and inhibitory conditions were not isolated. There was some indication, however, which suggested that, if the exposure to the segments by daily wearing or by more trials were longer, an effect might have been demonstrated. It appears that there are no immediate decisive effects of the segments on a normal subject's ability in either vertical or standing broad jumping. This conclusion, however, does not negate the use of the segments for learning because it may be discovered that with longer exposure learning, too, could be affected. Indeed, there is evidence (14,19) that spinal level synaptic learning is possible, and it is reasonable to assume that, as in cortical learning, exposure enhances the effect. In this current case, continued wearing of the segments could, for example, by continuous stimulation condition motor cells to reduce synaptic inhibition and to allow the recruitment of more and more motor cells, which, once involved in the pattern, would continue to be involved (47,54). The gamma loop as well could perhaps be "educated" to use an external stimuli such as the orthokinetic segments (33).

While the analysis was not statistically significant at the .01 level and therefore no firm conclusions may be drawn, inspection of figures 4 and 5 shows that in almost every instance the treated groups, inhibitory as well as facilitatory, performed at levels greater than the control group. Only on day 2, Phase I in the vertical jump and day 5, Phase II in the standing broad jump did the control group performance level exceed that of any treated group. This picture suggests the possibility that an orthokinetic wrapper of the current design worn in <u>any</u> position, if worn long enough, might cause a significant effect on the wearer's performance. The effect of the segments as simply a one-effect wrapper which has exteroceptor stimulating characteristics is found to have support in other research. It has been shown that exteroceptors override or have a stronger influence upon nervous system functioning than proprioceptors (60).

It must be noted that the "wrapper" in this experiment had both elastic and inelastic portions and that, while no positioning of the fields of the wrapper proved significant, the construction of the wrapper may still have been important. The results of this experiment do not provide any additional information to help answer the question of how the exteroceptors interpret their environment.

A tendency was demonstrated in the between group trends of Phase I of the standing broad jump criterion measure which suggested that the segments might be found to have specific inhibitory effects. The pairings of the groups in Phase I showed trends which allow again for the suggestion that, if the exposure were to have been longer, there may have been developed significant and predictable differences in the effects of the various placings of the segments for inhibition. There remains, then, the possibility that orthokinetic effects as outlined by Dr. Blashy and as envisioned in this study do exist. It appears that the most important single factor in the isolation of the effects may be some sort of longer exposure of the subjects to the segments.

Competitive spirit. In the course of the testing the investigator observed that there was a competitive factor operative. In spite of the experimental atmosphere and no open or verbally reënforced competitive elements, it appeared possible that some subjects might have been trying harder and some might have "given up" and not tried their best because of comparisons with neighboring subjects. There is also the possibility that a highly competitive subject when in the inhibited condition may have occasionally exerted an unusually strong cortically-oriented effort to compete against his own previous scores.

It is possible that the segment effect, then, which is thought to be operative at the spinal level, might have been overridden or masked to some extent by cortical intervention due to ideas of competition by the subjects.

Cortical intervention. Also the character of a criterion measure or the fact of testing itself may cause critical presynaptic inhibition by cortical intervention which impedes the skin signals in the spinal synapses; thus, orthokinetic treatment may be found to have plentiful effect clinically with sick persons or practically in a gymnasium training session but may be more difficult to isolate in research. The mechanisms of "spinal learning" suggest a possible answer to the research problem. Perhaps if the subjects wore the segments all day, the longer exposure would result in an enhanced willingness of the organism to accept their stimuli when performing tests. Working the subjects to fatigue may perhaps be another method in which the central nervous system can be induced to relax its cortical intensity in favor of more primitive processes (41).

Orthokinetic treatment and the state of subjects. At least in the United States, this study apparently made the first use of orthokinetic segments on healthy and nondisabled persons. The failure of the experiment to affirm strongly the successes of Drs. Fuchs and Blashy with clinical patients immediately suggests that the state of the subjects may be a critical factor in the effectiveness of orthokinetic segments. And concepts are available from various fields related to neurophysiology to support at least a tentative belief along such a line (6, 18 ,32,58,66).

It was observed that several daily-varying factors seemed to affect the students individually and as a whole. Lack of sleep, bad colds, and minor sport's injuries were seemingly small in incidence, but, on the other hand, these conditions which alter nervous sensitivity or general performance ability are not readily observable. The somewhat erratic plot of the group means in the graphs shows 1) that there is a fair amount of daily variance in jumping ability, and 2) that all subjects--by comparing the subjects by groups --seem to be affected the same on certain days such that they all jump slightly better or worse. Many factors can be thought of with respect to this population which may be used to explain these results. Weather conditions, such as humidity and atmospheric pressure, and the environmental conditions of the university campus, such as test periods and homecoming weekends in which the students change their emotional and daily living routines, would appear with this population to be important considerations to a study of orthokinetics. Research on acupuncture (1) directly related skin sensitivity to general health, and the clinical successes of Doctors Fuchs (32) and Blashy (6) suggest that a functionally depressed state of health may increase the organism's receptivity to therapeutic nervous stimulation.

Criterion measures. As has been observed, the vertical and standing broad jumps may be sensitive to environmental conditions and individual differences in health; thus a very restricted test seems indicated. On the other hand, if the segments are to have a general usefulness, they should be operative with performance tests such as these jumps which are closely related to general human motility. Also, if the kinetic chains of Fuchs are operative, the whole body should be free to move in any test. A choice of criterion measures for research must perhaps be based on many limiting factors, but ultimately a somewhat gross application must be found for practical usefulness.

Construction of the segments. Dr. Fuchs's segments were of calf skin and thus the elastic and inelastic portions were directly against the skin. While it is true that Dr. Blashy found clinical effects with elastic bandaging material in which the rubber is first in contact with cloth threads, it may be that as in Fuchs's segments the stretch characteristics of the segment should be in intimate contact with the skin for optimum results. Sheet rubber might be a good segment material. Perhaps it could be rendered inelastic by chemicals in certain areas so as to be personally constructed for each subject. By the same reasoning, stretching in two planes--up and down as well as sideways--may enhance the effect.

CONCLUSIONS

The purpose of this investigation was to assess the effects of orthokinetic segments upon motor responses of normal male college students. According to underlying theory proper use of the orthokinetic segments, which are wrappers

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made with elastic and inelastic fields, should have demonstrated selective facilitation and inhibition of muscular response. The proper stimulation of the skin covering the entire musculature of the thighs should have affected the responses of the underlying muscles by involvement of the central nervous system at the spinal level.

This orthokinetic experiment was prompted by the publications of Drs. Julius Fuchs and M. R. M. Blashy. A review of related literature indicated that not only was such an experiment likely to meet with success but also it would make a valuable contribution to numerous fields of endeavor ranging from research on neurophysiology to application in physical education and therapy.

Within the limits of the study the following general conclusions may be drawn:

1. Taken as a whole the study failed to demonstrate the presence of orthokinetic segment effects upon motor responses of normal male college students. This result does not deny the possibility of such effects. It appeared that many factors such as competitive spirit, cortical intervention, and state of the subjects in health and sickness may have critically influenced the attempted isolation of the effect.

2. In the vertical jump, separate trend analysis of the control group paired with the facilitated group during Phase I gave some indication that an orthokinetic effect on mean performance levels might have been found to be statisti-

cally significant if the subjects had had longer exposure to the segments, such as by all-day wearing. It was found to be conceivable, at least, that orthokinetic segments might have the effect of producing faster achievement of maximum performance levels. All other possible pairings in the vertical jump during Phase I, however, did not produce significant trend interactions, and the same control and facilitated groups paired in the standing broad jump during Phase I failed to corroborate the indication.

3. In the standing broad jump, separate trend analysis of the control group paired with both the rotary exercise inhibited group and the inhibited group during Phase I gave some indication that an inhibitory effect of orthokinetic segments on mean performance levels might have been found to be statistically significant if the subjects had had longer exposure to the segments, such as by all-day wearing.

4. While the performance of the treated groups did not demonstrate a statistically significant difference in mean performance levels, the possibility of a simple facilitatory effect of the segments regardless of the position of the fields was suggested by the dominant performance levels of the treated groups over the control group in both criterion measures in all phases. On all but two trial days the mean performances of the treated groups exceeded those of the control groups. Again, it appeared that the isolation of such a one-effect wrapper may depend on longer exposure of the subjects to the segments. Also, while the effect may have been limited to facilitation

in this regard, the current construction of the segments with both elastic and inelastic fields may still be a critical factor in the production of effect.

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